Government of **Western Australia**
Department of **Water**

Decision process for stormwater management in WA:

Draft for consultation

July 2016

Securing Western Australia's water future

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A component of Chapter 4: Integrating stormwater management approaches, Stormwater Management Manual for Western Australia (Department of Water 2004-2007)

Securing Western Australia's water future

Department of Water

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1 Introduction

1.1 Why is this document needed?

Urban development should be designed to ensure that liveable, resilient, sustainable and productive cities and communities are created by interconnecting the built, social and natural environments. Urban stormwater management is a significant component in creating water sensitive cities and communities.

The desired outcomes of the *Decision process for stormwater management in WA* are for urban stormwater management systems to be planned and designed to achieve the following:

- Protect public health and safety.
- Protect public and private infrastructure and buildings from flooding.
- Protect and enhance sensitive receiving environments by managing the water cycle, water quality, habitat diversity and biodiversity.
- Provide economically sustainable construction, maintenance and renewal/replacement costs.
- Achieve good urban amenity.

These outcomes can be achieved by:

- designing urban stormwater management systems that minimise risk to people and property from flooding
- designing urban stormwater management systems that mimic natural hydrological processes for that catchment
- retaining natural water bodies as the receiving environments for runoff from minor and major rainfall events
- retaining and planting vegetation wherever possible to reduce stormwater runoff volumes and peak flow rates, reduce urban temperatures, improve water quality, increase urban biodiversity, and improve aesthetics and urban amenity
- implementing stormwater management systems and site management, maintenance and other practices to prevent, reduce and treat pollutants
- designing urban stormwater management systems that achieve good urban amenity and provide multiple functions.

This document provides an approach and outcome criteria for planning and designing stormwater management systems for urban (greenfield, infill and brownfield) developments and when retrofitting existing stormwater management systems. This document does not require one type of design or method, as there are many ways of achieving the desired outcomes. Innovation is encouraged, especially at constrained and challenging sites.

This document is the third edition of the *Decision process for stormwater management in WA*, which was originally published in 2005 and previously updated in 2009. Development of this edition was also based on feedback from local governments and the urban development industry on how the process could be improved.

This update was developed to:

- apply current best practice international approaches and criteria for small rainfall event management
- review requirements for the north-west and north of Western Australia when applying the 1-year, 1-hour average recurrence interval rainfall event criterion to avoid over-sized systems
- consider shallow groundwater management at the beginning of the stormwater management decision process
- strengthen the case for small rainfall event management to be considered early in the design of urban stormwater management systems
- incorporate the new rainfall event terminologies from Engineers Australia's review of *Australian rainfall and runoff*
- explain how to include natural hydrological processes in stormwater management
- provide an explanation of stormwater management relating to management of receiving water bodies and their buffers
- consider urban liveability and amenity in the design of stormwater and shallow groundwater management systems
- provide updated information on stormwater management in the land and water planning process.

The decision process sits within the objectives, principles and delivery approach outlined in the *Stormwater management manual for Western Australia* (Department of Water 2004–07).

1.2 Who should use this document?

This document should be used by local governments, water service providers and the urban development industry to design urban stormwater management systems. It should also be used by state and local government officers to assess urban stormwater management systems.

1.3 How to use this document?

The document includes two key figures. Figure 1 shows the process of integrating stormwater management into the land-use planning system. Figure 2 illustrates the processes and criteria for stormwater management in Western Australia to aid those designing and assessing the urban form.

New to this document is a suite of conceptual diagrams (figures 3–16) that visually represent the logic of stormwater management at different site conditions and at the lot, public open space and estate scales. These diagrams provide examples and are not intended as one-size-fits-all solutions.

Section 2 provides information on stormwater management responsibilities in Western Australia. Section 3 includes information explaining the stormwater management logic and approach. An explanation of the new stormwater quantity criteria for small, minor and major rainfall events is included in Section 4, including why those criteria were selected and comparisons with the criteria published in the 2009 edition of the *Decision process for stormwater management in WA*.

2 Stormwater management governance

The Department of Water is Western Australia's water resource management agency. For stormwater management, the Department of Water:

- provides floodplain mapping for major river systems
- prepares drainage and water management plans
- provides Western Australian stormwater management criteria and guidelines
- provides water management and design advice on the state government's strategic and special projects
- assesses water management strategies and plans prepared under the *Better urban water management* (Western Australian Planning Commission 2008) process.

Local government is responsible for the management of local drainage networks in Western Australia. Local government assesses urban development proposals, constructs local road and drainage systems, and maintains drainage networks. See the *Local government guidelines for subdivisional development* (Institute of Public Works Engineering Australia WA Division Inc. 2012) for local government subdivision and drainage management guidelines.

The Water Corporation is the service provider of urban main drainage infrastructure in some parts of the Perth metropolitan region and arterial rural drains in some parts of the south-west of Western Australia. The Water Corporation assesses urban development proposals when they are in a drainage catchment containing Water Corporation drainage infrastructure.

For more detailed information on the roles of various stakeholders in stormwater management, see Section 6, Chapter 2, *Stormwater management manual for Western Australia* (Department of Water 2004).

3 Stormwater management approach

When land is urbanised, the impervious area increases and the vegetation decreases, resulting in additional runoff, less infiltration and less evapotranspiration. These hydrological changes result in:

- increased risks to people and properties from flash flooding
- increased runoff volumes to manage in the urban landscape
- impacts on the ecology of receiving water bodies.

The water sensitive stormwater management approach examines how runoff from small rainfall events is managed *and* how runoff generated by minor and major rainfall events moves through the urban landscape. Lots, roads, parks and water bodies are all locations where stormwater is managed. When designing stormwater management systems, it is important to focus on what occurs most often, while understanding and planning for what occurs less frequently. The design process should design for the small, then minor, then major rainfall events and aim to replicate how water moves in the natural landscape.

Mimicking natural hydrological processes is an integral component of the water sensitive approach to stormwater management. See Section 3.1 for more information.

The water sensitive approach to stormwater management also involves preventing and reducing pollution through the implementation of non-structural controls (see Chapter 7, *Stormwater management manual for Western Australia*, Department of Water 2005). It also involves the implementation of structural controls throughout the catchment to prevent and treat pollution (see Chapter 9, *Stormwater management manual for Western Australia*, Department of Water 2007).

Achieving good urban amenity is another important component of water sensitive stormwater management systems. This can be achieved by:

- integrating stormwater management systems within the design of road reserves and public open space
- reducing urban temperatures, runoff volumes and peak flow rates, and improving water quality, biodiversity and aesthetics by managing stormwater within the urban landscape and through retaining and planting vegetation
- establishing a connection between people, water and nature in the urban landscape.

See Section 4.2 and Figure 2 for more information about achieving good urban amenity.

To ensure that stormwater management is integrated with urban water management and land-use planning, stormwater management system design is included in the land and water planning process. See Section 3.2 and Figure 1 for more information.

The other integral stormwater management approach is to design site-specific stormwater management systems. See Section 3.3 for more information.

3.1 Mimic natural hydrological processes

Scientific and case study investigations find that when stormwater management systems minimise changes to and mimic natural hydrological processes, the best economic, social and ecological outcomes are achieved (see references later in this document). These natural processes are influenced by the site's geology, topography, climate and vegetation cover and include:

- minimal runoff during small rainfall events
- high evapotranspiration
- significant groundwater recharge on sandy sites
- overland runoff during minor and major rainfall events.

How to mimic natural hydrological processes

- *Retain natural water bodies.*

  Natural water bodies are integral components of natural hydrological processes and receiving environments for runoff from minor and major rainfall events. Water bodies and their buffers or foreshore areas reduce the risk of flooding houses and infrastructure due to their capacity to store runoff from large rainfall events.

  Furthermore, to reduce flooding and receiving water quality impacts, stormwater should not be discharged directly into water bodies and should not bypass vegetated buffers around wetlands and vegetated foreshore areas next to waterways and coastal marine areas (Figure 2).

- *Retain and plant vegetation wherever possible.*

  Vegetation will reduce stormwater runoff volumes and peak flow rates (due to rainfall capture in the canopy resulting in more evaporation and rainfall use via transpiration), reduce urban temperatures (and the urban heat island effect – see Cooperative Research Centre for Water Sensitive Cities 2014a and 2014b for more information), improve water and air quality, increase urban biodiversity, and improve aesthetics and urban amenity.

  Vegetation should include trees (particularly trees that maintain a wide canopy during the wet season) and understorey vegetation. Vegetation can be incorporated within drainage management systems with the use of green roofs/walls, tree pits, biofilters, vegetated swales, living streams, infiltration basins/areas, detention basins/areas and constructed wetlands. Vegetation should also be incorporated within gardens, carparks, road reserves and public open space.

- *Minimise the 'effective imperviousness' of a development area.*

  Effective imperviousness is the combined effects of the proportion of constructed impervious surfaces in the catchment ('total imperviousness') and the connectivity of these impervious surfaces to receiving water bodies ('drainage connection'; Walsh et al. 2004).

  Minimising effective imperviousness mimics pre-development hydrology and reduces the transport of pollutants to receiving water bodies (Burns et al. 2014). Additional benefits of more overland flow and less piped flow are: reduced chances of pipe blockages and consequent unintended flooding of buildings and private properties; reduced capital expenditure; and easier inspections.

To minimise effective imperviousness, pervious surfaces should be retained and installed wherever practical. Additionally, constructed impervious surfaces should be disconnected from receiving water bodies (preventing direct stormwater discharge via pipes and drains) and disconnected from other constructed impervious surfaces by using overland flow wherever practical.

- *Manage small rainfall event runoff at-source.*

  Managing the runoff from small rainfall events at-source prevents the collection and downstream transportation of pollutants. If water throughout the catchment is collected and transported to a point some distance downstream for retention and treatment, often impractically large areas would be required to allow sufficient infiltration or evaporation (Walsh et al. 2004; Burns et al. 2012). Ladson et al. (2004) stated that retaining or detaining stormwater from small rainfall events is the critical factor in reducing urban runoff impacts. They stated that increased total catchment imperviousness would still generate greater flows from larger rain events than those from the pre-urban state (and probably associated with higher levels of pollutants) but the frequency of these events would be in line with the pre-urban runoff characteristics. The ecological impacts of these larger events may be relatively small because they are closer to the type of disturbances that aquatic plants and animals have adapted to.

  Small rainfall event runoff should be treated (if required), infiltrated, used, evaporated or detained at-source or as close to the runoff source as possible. Less development space is required when runoff is managed closer to source. When small rainfall event runoff cannot be managed at-source, overland flow paths should be designed wherever practical to allow the runoff to reach the next available area. This could include flow from a lot, to a road reserve and then to a park.

- *Provide overland flow paths wherever practical*.

  Overland flow paths slow runoff velocity, reduce runoff volume due to increased evaporation, and improve stormwater quality when the overland flow path is vegetated. By slowing runoff velocity and reducing runoff volume, people and property are more protected from minor and major rainfall event runoff.

  Examples of overland flow paths are swales, living streams and vegetated buffers to water bodies.

- *Incorporate the forms and processes of natural water bodies within stormwater management systems.*

  This improves the stormwater management systems' biodiversity values, water quality treatment capabilities, amenity values and resilience to extreme weather events.

  For example, living streams mimic natural watercourses due to their intermittent flooding in the floodplain section and their meandering course. Vegetated swales can be designed to mimic ephemeral streams and constructed wetlands can be designed to mimic natural wetlands.

For more detail on the issues associated with conventional conveyance drainage management systems, as well as the water sensitive approaches to stormwater management, see Chapter 2, *Stormwater management manual for Western Australia* (Department of Water 2004); Engineers Australia (2006); Burns et al. (2012 and 2014); Melbourne Water (2013); United States Environmental Protection Agency (2014).

3.2 Integrate stormwater management in the land and water planning process

To integrate urban water planning and management with land-use planning and development, water management strategies or plans should be prepared in accordance with:

- *Better urban water management* (Western Australian Planning Commission 2008)
- *Guidelines for district water management strategies* (Department of Water 2013d)
- *Interim: Developing a local water management strategy* (Department of Water 2008a)
- *Urban water management plans – guidelines for preparation and compliance with subdivision conditions* (Department of Water 2008b).

Better urban water management (Western Australian Planning Commission 2008) was developed to assist the land development industry to demonstrate compliance with the policies and principles of *State planning policy no. 2.9: water resources* (Western Australian Planning Commission 2006). A series of guidance notes (Department of Water 2013a) have been developed to assist with implementation of *Better urban water management* (Western Australian Planning Commission 2008).

Further guidance on the integration of urban water planning and management with land-use planning and development can be found in *Liveable neighbourhoods* (Western Australian Planning Commission and Department for Planning and Infrastructure 2009).

A key focus for stormwater management when preparing district and local water management strategies is allocating the land area required for small, minor and major rainfall event management. The focus for stormwater management in urban water management plans is to provide detailed stormwater management infrastructure requirements. Each strategy or plan should provide sufficient detail to enable an informed decision to be made in relation to the land planning level, the significance of the receiving environment and the level of risk to water resources and community assets associated with the proposal.

Figure 1 *Stormwater management and the land and water planning process* shows the steps for stormwater management planning in relation to *Better urban water management* (Western Australian Planning Commission 2008). Figure 2 provides the process and criteria for stormwater management planning and design.

3.3 Design stormwater management systems based on the local site parameters

The design of stormwater management systems should be based on adequate investigations to ascertain the site conditions because site-specific solutions are often required.

Variations to the criteria provided in Figure 2 could be considered if it can be demonstrated that there is a more sustainable approach to achieving the criteria outcomes. Consult with the Department of Water early in the design process if modifications to the criteria are being considered.

Teams that design and assess stormwater management systems should be multi-disciplinary, comprising engineers, landscape architects, planners, environmental scientists and maintenance staff.

Consider the management of shallow groundwater (where present) early in the stormwater management design process. The process and considerations for a groundwater management system are detailed in *Water resource considerations when controlling groundwater levels in urban development* (Department of Water 2013e).

Chapters 6, 7 and 9 of the *Stormwater management manual for Western Australia* (Department of Water 2004–2007) outline how to select and design individual components of stormwater management infrastructure and associated management systems.

4 How should rainfall events of different sizes be managed?

Figure 2 outlines stormwater quantity criteria. Further detail is provided below.

4.1 Small rainfall events – ecological protection

Manage water quality

- *Manage (retain and/or detain) stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.*
  - Lot runoff should be managed within lots and road runoff should be managed within road reserves.
  - Where site conditions do not allow for the full runoff to be managed at-source, manage as much as practical at-source. The remaining runoff should be conveyed from a lot or road reserve via overland flow wherever practical.
- *Install water quality treatment infrastructure at the conveyance outlet when small rainfall event runoff from constructed impervious surfaces directly enters a piped/lined channel conveyance system.*

Runoff generated from the first 15 mm of rainfall can mobilise substances such as soluble materials, fine dusts and silts, oils, grease and other non-volatile hydrocarbons from constructed impervious surfaces (New South Wales EPA 2013).

Managing the runoff generated from the first 15 mm of rainfall at the runoff source (i.e. 'at-source') will reduce the transportation of pollutants downstream. Managing small rainfall event runoff at-source also reduces the volume of stormwater discharged downstream that would require treatment, which reduces the size of downstream stormwater quality treatment devices. If all runoff is transported off-lots to road reserves or public open space, the water quality treatment area would occupy a larger area of the road reserve or public open space than if the runoff from the first 15 mm of rainfall was managed at-source. This would transfer capital and maintenance costs to systems managed by local governments.

Note that managing runoff from small rainfall events within road reserves will require road reserves of width sufficient to accommodate stormwater management systems.

A review of international and national approaches found that many jurisdictions adopted a similar approach, where a rainfall depth value (rather than a rainfall event value) is used, as well as first flush interception and management of small rainfall events at-source. See Department of Environment and Resource Management (2010), Christchurch City Council (2012) and United States Environmental Protection Agency (2011) for additional information.

Comparison to the previously published criterion

The criterion published in the 2009 version of the *Decision process for stormwater management in WA* (Department of Water 2009) was: retain or detain stormwater runoff from constructed impervious surfaces generated by up to 1-year, 1-hour average recurrence interval (ARI) events on-site (i.e. as high in the catchment and as close to the source as possible).

The criterion published in *Stormwater design considerations* (Department of Water 2011) was: retain or detain stormwater runoff from constructed impervious surfaces generated by up to the 1-year, 1-hour ARI event at its source, preferably in lots and road reserves.

The 15 mm criterion replaces the previous 1-year, 1-hour ARI rainfall event criterion. The 1-year, 1-hour ARI criterion resulted in over-sized systems for water quality management for areas in the north-west and north of Western Australia. For example, 37 mm of rainfall would need to be managed at-source in Kununurra under the 1-year, 1-hour ARI criterion, much larger than the volume required for water quality management. In Perth, Busselton and Carnarvon, the 1-year, 1-hour ARI criterion resulted in 16 mm of rainfall to be managed at-source. The 15 mm criterion enables initial water quality objectives to be met under many practical circumstances.

Maintain sensitive receiving environment form and hydrology

- *Maintain pre-development peak flow rates and total volume runoff from the outlets of the development area for the critical 1 exceedance per year (EY) event.*

This will assist with protecting the ecological values of sensitive receiving environments, by maintaining the pre-development hydrological regime and maintaining waterway channel form and stability.

The criterion for managing the runoff from the first 15 mm of rainfall at-source also assists with maintaining the pre-development hydrology of the site. This is because small rainfall events in natural catchments generally do not produce overland flow/runoff; instead, the rainfall either infiltrates into the ground (subsequently recharging groundwater in some sites) or evaporates. Where piped stormwater conveyance systems are used to manage minor rainfall event runoff, managing small rainfall events at-source will significantly reduce the frequency of flows that affect downstream receiving environments.

Comparison to the previously published criterion

The criterion published in the 2009 version of the *Decision process for stormwater management in WA* (Department of Water 2009) was: detention systems should preserve the pre-development critical 1-year ARI peak flow rate and discharge volume for the catchment.

The criterion published in *Stormwater design considerations* (Department of Water 2011) was: maintain pre-development peak flow rates and total volumes runoff from the whole sub-catchment at outlets from the site at the critical 1-year ARI event. As a proponent usually has limited or no control over the stormwater management systems for a whole catchment or sub-catchment, use of the term ‘catchment’ was deemed inappropriate. Additionally, ‘development area’ replaces ‘site’ due to varying interpretations of the meaning of ‘site’. Some interpret ‘site’ as meaning ‘lots’, while others interpret ‘site’ as meaning ‘development area’.

The intention of this criterion was to apply to the development area. The critical 1 EY event is equivalent to the critical 1-year ARI rainfall event. Replacement of ARI with EY reflects the new methodology and terminology proposed for this rainfall event size in the review of *Australian rainfall and runoff* (Engineers Australia n.d.).

4.2 Minor rainfall events – serviceability, amenity and road safety

Provide serviceability, amenity and road safety

- *Design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.*

Once the small rainfall event management systems and areas have been designed, the effects of minor rainfall events on transport networks, public open space and drainage networks should be assessed. Consult with service providers at the beginning of the design process. Providers of transport networks (local government, Main Roads WA and Public Transport Authority), public open space (local government) and drainage networks (local government and Water Corporation) should define the relevant design exceedance per year (EY) or the annual exceedance probability (AEP).

Designers should refer to *Australian rainfall and runoff* (Engineers Australia 2016) for information on how to design minor rainfall event management systems. Chapters 3 and 6 of Book 9 of *Australian rainfall and runoff* (Engineers Australia 2016) do not provide rainfall event sizes for minor rainfall event management; instead Book 9 refers readers to the relevant consent authority for applicable rainfall event sizes and provides example AEPs for various land use types. Design rainfall events based on road hierarchy are provided in *Liveable neighbourhoods* (Western Australian Planning Commission and Department for Planning and Infrastructure 2009) and *Local government guidelines for subdivisional development* (Institute of Public Works Engineering Australia WA Division Inc. 2012).

Comparison to the previously published criteria

The criterion published in the 2009 version of the *Decision process for stormwater management in WA* (Department of Water 2009) was: design for greater than 1-year and less than/equal to 5-year (residential/rural-residential) or 10-year (commercial/industrial) ARI events. The criteria published in *Stormwater design considerations* (Department of Water 2011) were: greater than 1-year ARI and up to 5-year ARI events for residential and rural-residential, and 10-year ARI events for commercial and industrial areas; attenuate critical 5-year event flows to the capacity of downstream natural channels or constructed drainage infrastructure; and maintain serviceability of roads and infrastructure. As the infrastructure type determines the applicable design rainfall event, the infrastructure provider should specify the design rainfall event value.

4.3 Major rainfall events – flood protection

Manage catchment flooding

- *Implement the Department of Water published catchment plans (e.g. drainage and water management plans).*
- *Maintain the pre-development flood regime (flood level, peak flow rates and floodplain storage volumes) for catchments that do not have a published catchment plan. Alteration to the pre-development flood regime (while still maintaining the pre-development flood level) is dependent on the constraints of the catchment and receiving environments and requires assessment of the capacity of the entire system and impacts from the change in flood regime to the satisfaction of the Department of Water and other relevant agencies.*
- *Calculate the 1% annual exceedance probability (AEP) flood level, peak flow rates and existing floodplain storage volumes and delineate flow paths by applying appropriate investigation and modelling for the development area.*

Once the small and minor rainfall event management systems have been designed, examine how runoff from major rainfall events moves through the urban landscape.

The 'manage catchment flooding' criteria will assist to protect people and property from flooding and prevent additional inundation of water bodies by preventing increased flood levels within and downstream of the development area.

Comparison to the previously published criteria

The criterion published in the 2009 version of the *Decision process for stormwater management in WA* (Department of Water 2009) was: maintain the pre-development annual discharge volume and peak flow, unless otherwise established through determination of ecological water requirements for sensitive receiving environments. The criteria published in *Stormwater design considerations* (Department of Water 2011) were: identify flow paths during urban design; and reduce risk of flooding and manage flow rates. Flood level was added to the major rainfall events criteria because flood level is invariably the critical aspect for managing urban development impacts from catchment flooding. The 2009 criterion also required modification to specify the rainfall event size because maintenance of the pre-development regime should not be applied to all rainfall event sizes.

Prevent building inundation

- *Protect people and property from flooding by constructing residential, commercial and industrial building habitable floor levels at least 0.3 m above the 1% annual exceedance probability (AEP) flood level of the urban drainage system and at least 0.5 m above the 1% annual exceedance probability (AEP) flood level of waterways, or as documented in a published plan, or based on advice from the Department of Water.*

This will assist with preventing building inundation by constructing habitable floor levels minimum distances above the 1% AEP flood level.

Important community facilities, such as hospitals, require more freeboard or design for clearance from larger rainfall events due to the increased consequences from flooding.

Table 7.3.2 of Queensland's Department of Energy and Water Supply et al. (2013) provides guidance on sensitive community facilities.

The 0.3 m freeboard between the 1% AEP flood level of the urban drainage system and building habitable floor levels is published in the *Urban main drainage standard* (Water Corporation 2011) and *Local government guidelines for subdivisional development* (Institute of Public Works Engineering Australia, WA Division Inc. 2012). The 0.5 m freeboard between the 1% AEP flood level of waterways and building habitable floor levels is published in *Water facts 14: Floodplain management* (Water and Rivers Commission 2000b) and *Local government guidelines for subdivisional development* (Institute of Public Works Engineering Australia, WA Division Inc. 2012).

Comparison to the previously published criterion

The 1% AEP event is equivalent to the 100-year ARI rainfall event. Replacement of ARI with AEP reflects the new methodology and terminology proposed for this rainfall event size in the review of *Australian rainfall and runoff* (Engineers Australia n.d.).

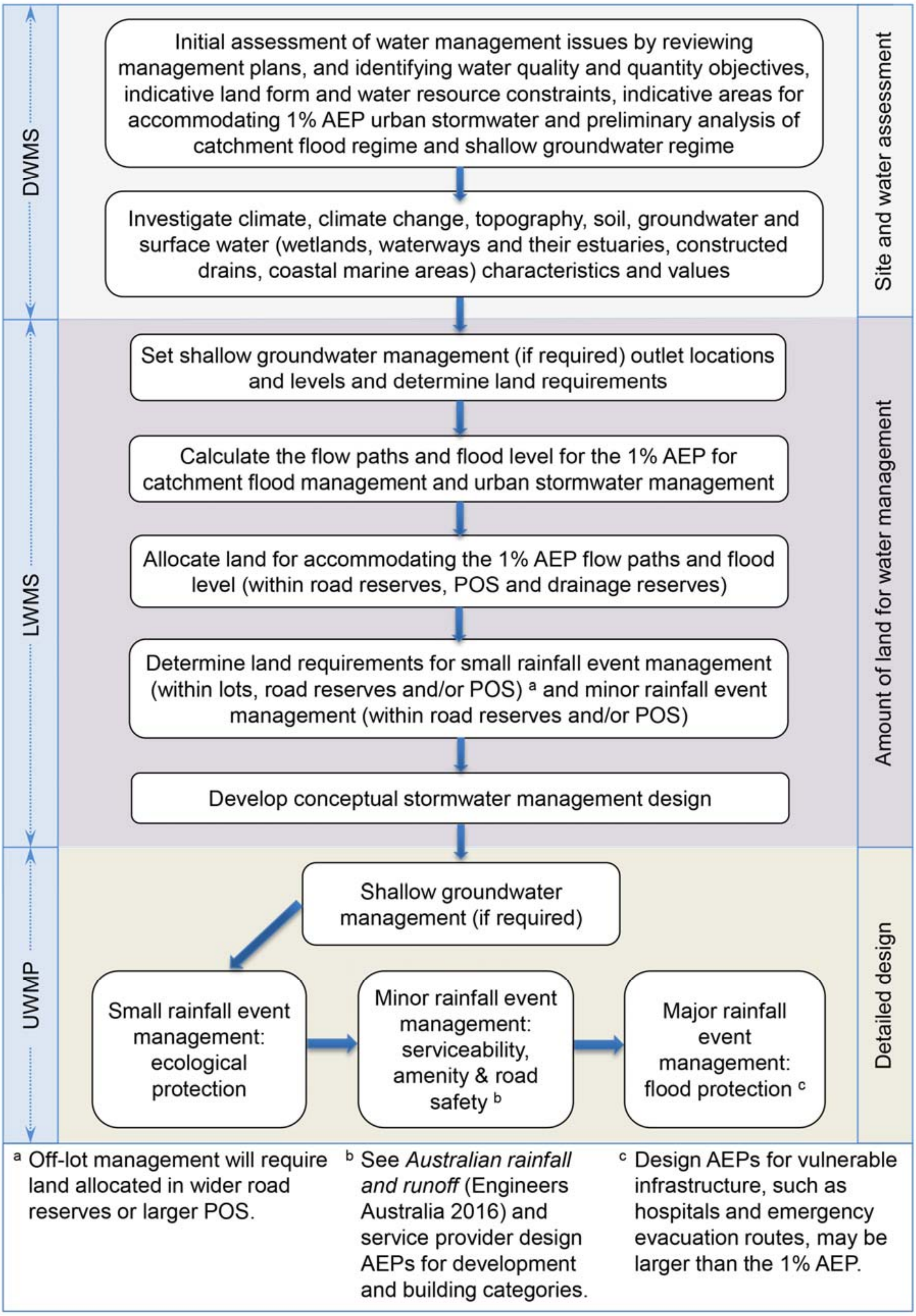

Figure 1 Stormwater management and the land and water planning process

Consult with stakeholders

Consult with local government authorities, Department of Water (DoW), Department of Parks and Wildlife (DPaW), Department of Environment Regulation (DER), Water Corporation or other water service provider (where applicable), local indigenous groups and other relevant stakeholders prior to and throughout the design process.

Review policies and guidelines

Review local and state government land and water management policies and guidelines.

Identify water issues

Identify water related issues that may require management in the proposed development or project.

Conduct desktop investigation

Conduct a preliminary desktop investigation by reviewing published management plans and reports[1].

Detailed investigation

Conduct a detailed investigation and evaluation of water related issues, groundwater, surface water flows, sensitive receiving environments[2], soil characteristics (e.g. infiltration rates) and contaminant/nutrient levels. This should include desktop and field investigations and monitoring of groundwater and surface water quality and quantity in accordance with DoW (2012b), including seasonal groundwater levels and surface water-groundwater interactions, and a total water cycle balance (especially in shallow groundwater areas).

Manage contaminated soil and groundwater

1. Is the proposal completely or partly within a known contaminated site either listed on the contaminated sites register (request a DER Basic Summary of Records Form 2 to check) or identified through adequate field investigations, or completely or partly within Class 1 high to moderate risk of acid sulfate soil occurrence as depicted on a DER acid sulfate soils risk map?
2. Does the soil or groundwater contain elevated contaminant/nutrient levels? Review applicable state and local government water management plans[1] and the requirements of sensitive receiving environments[2] for acceptable contaminant/nutrient levels. In the absence of already established local catchment targets, the ANZECC/ARMCANZ (2000) guidelines provide a guide for water quality targets.

No

Manage shallow groundwater

- Assess the groundwater regime, including the impact of urban development on groundwater levels and of groundwater levels on the urban form.
- Assess if groundwater level management is required. Design a controlled groundwater level system in accordance with DoW (2013e).

Yes

Avoid mobilisation or disturbance of in-situ contaminants

1. Seek further advice from Department of Environment Regulation.
2. Seek further advice from Department of Water and Department of Parks and Wildlife (where applicable).

Manage stormwater quantity | **Manage water quality** | **Protect and manage water bodies** | **Achieve good urban amenity**

Manage stormwater quantity

Manage runoff from small rainfall events for ecological protection

- Minimise effective imperviousness by installing pervious surfaces and diverting runoff from impervious surfaces to pervious surfaces wherever practical.
- Reduce the volume of runoff and delay the peak flow rate by minimising effective imperviousness and providing retention and detention areas at the runoff source wherever practical.
- Manage (retain and/or detain[3]) stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical[4]. Lot runoff should be managed within lots and road runoff should be managed within road reserves. Where site conditions do not allow for the full runoff to be managed on-lot, manage as much as practical at-source. The remaining runoff should be conveyed from a lot or road reserve via overland flow wherever practical. Designs should be site-specific.
- Install water quality treatment infrastructure at the conveyance outlet when small rainfall event runoff from constructed impervious surfaces directly enters a piped/lined channel conveyance system.
- Maintain pre-development[5] peak flow rates and total volume runoff from the outlets of the development area for the critical 1 exceedance per year[6] (EY) event.

Manage runoff from minor rainfall events for serviceability, amenity and road safety

- Design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events. Once the small rainfall event management systems and areas have been designed, the effects of minor rainfall events on transport networks, public open space and drainage networks should be assessed. The minor rainfall event management system should be designed to provide serviceability, amenity and road safety (for pedestrians and vehicles). Providers of transport networks, public open space and drainage networks should define the relevant design exceedance per year (EY) or the annual exceedance probability (AEP). Consult with service providers at the beginning of the design process. See Department of Energy and Water Supply et al. (2013) for design rainfall event guidance and examples. Also consult Engineers Australia (2016) for guidance on minor rainfall event management.

Manage runoff from major rainfall events for flood protection

- Implement the DoW published catchment plans (e.g. drainage and water management plans).
- Maintain the pre-development flood regime (flood level, peak flow rates and floodplain storage volumes) for catchments that do not have a published catchment plan. Alteration to the pre-development flood regime (while still maintaining the pre-development flood level) is dependent on the constraints of the catchment and receiving environments and requires assessment of the capacity of the entire system and impacts from the change in flood regime to the satisfaction of the Department of Water and other relevant agencies[7].
- Calculate the 1% annual exceedance probability[8] (AEP) flood level, peak flow rates and existing floodplain storage volumes and delineate flow paths by applying appropriate investigation and modelling for the development area.
- Protect people and property from flooding by constructing residential, commercial and industrial building habitable floor levels at least[9] 0.3 m above the 1% AEP flood level of the urban drainage system and at least[9] 0.5 m above the 1% AEP flood level of waterways, or as documented in a published plan, or based on advice from the DoW.
- Safely convey the critical 1% AEP event flow through natural water bodies and constructed stormwater conveyance systems (e.g. providing overland flow from lots to road reserves; overland flow along roads and road reserves; public open space detention and conveyance systems; living streams; wetlands; and waterways).

Infrastructure design

- Incorporate the methodology of Engineers Australia (2016) for hydrologic and hydraulic analyses, safety analyses, modelling and design, including accounting for losses and hydraulic structure blockage.
- See DoW (2004–2007) and the stormwater page on the DoW website <www.water.wa.gov.au> for guidance.
- Prevent disease vector and nuisance insects breeding by designing stormwater management systems to contain no standing water for more than 96 hours.
- Distribute retention and detention areas at the runoff source, along the conveyance flow paths and at the end of the catchment.
- Reduce the volume of runoff and delay peak flows by minimising effective imperviousness and providing retention and detention areas at the runoff source.

Manage water quality

- Install water quality treatment measures at controlled groundwater level subsoils and drains and/or at outlet points, unless investigations demonstrate that treatment is not required (see DoW 2013e).
- Implement stormwater quality management measures throughout the development area. Use a combination of non-structural and structural controls to prevent, reduce and treat pollutants. See DoW (2004–2007) and the stormwater page on the DoW website <www.water.wa.gov.au> for guidance.
- Manage (retain and/or detain[3]) stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall as much as practical at the runoff source so that the transportation of pollutants and the volume of water to be treated are reduced.
- Convey stormwater runoff overland where practical within road reserves and public open space, preferably through vegetation.
- Install water quality treatment infrastructure at the conveyance outlet when small rainfall event runoff from constructed impervious surfaces directly enters a piped/lined channel conveyance system.
- Determine the treatment required based on the quality of stormwater/surface water and mobilised/discharged groundwater, potential pollutant pathways towards receiving environments and on the requirements of receiving environments. Field investigations might be required to measure pre-development water quality of receiving environments. Water quality objectives should be based on applicable state and local government water management plans[1], and the requirements of receiving environments. In the absence of already established local catchment targets, the ANZECC/ARMCANZ (2000) guidelines provide a guide for water quality objectives. Demonstration of compliance with water quality targets that have been set by water quality improvement plans or similar plans will depend on the scale and nature of the proposed development. The UNDO tool has been developed by the Department of Water to assess the export of nitrogen and phosphorus from urban developments, which allows urban developers to quantify the magnitude of structural and non-structural controls required to reduce nutrient exports to within guideline values.

Protect and manage water bodies

- Identify all water bodies (wetlands, waterways and their estuaries, coastal marine areas and shallow groundwater aquifers) within the catchment of the proposed development area.
- Protect and, where appropriate, restore water bodies within the development area. For waterways, the approach to protection and management should be consistent with Water and Rivers Commission/Department of Environment (1999–2003) and DoW (2012a), and in the Swan and Canning catchments it should be consistent with SRT (2012). For wetlands, the approach to protection and management should be guided by and consistent with EPA (2008) and the approach to restoration should be guided by DEC (2013).
- Maintain pre-development surface water flow rates, runoff volumes and flood level and shallow groundwater recharge rates for receiving water bodies, unless otherwise established in an approved management strategy or plan[1] and subject to the advice of the relevant agency[7].
- Locate stormwater management infrastructure (including pipes, constructed drains, flood detention areas and vegetated swales) outside of conservation category wetlands/other wetlands of high conservation significance[2]/resource enhancement category wetlands and their buffers; and waterways/coastal marine areas and their foreshore areas. Where existing built infrastructure (e.g. roads) constrains stormwater infrastructure location and overland flow is insufficient for achieving pre-development hydrology, ecological water or water quality requirements, vegetated swales could be constructed within buffers or foreshore areas, subject to advice from the relevant agency[7]. For multiple use category wetlands, stormwater management shall be consistent with EPA (2008).
- Creation of ornamental lakes or ponds will not be supported. Refer to DoW (2007a) for further guidance.

Achieve good urban amenity

- Maintain or improve urban function, form and aesthetics by integrating urban design and stormwater management.
- Investigate stormwater and discharged controlled groundwater as a potential fit-for-purpose water source for irrigation and other water uses (see DoW 2013c).
- Establish a connection between people, water and nature, especially highlighting the ephemeral and variable characteristics of rainfall and runoff.
- Incorporate art within stormwater management infrastructure to improve aesthetics and to highlight the link between people and water.
- Incorporate vegetation wherever possible on buildings, on lots, in road reserves, in carparks, in public open space and in stormwater management infrastructure. This should include trees (particularly trees that maintain a wide canopy during the wet season) and understorey vegetation. Vegetation will reduce urban temperatures (and reduce the urban heat island effect – see Cooperative Research Centre for Water Sensitive Cities 2014a and 2014b), improve aesthetics and urban amenity, improve water quality, reduce stormwater runoff volumes and peak flow rates, and increase urban biodiversity.
- Integrate stormwater management infrastructure within public open space to protect and enhance public open space function (sport, recreation and nature) and hierarchy. Manage runoff from small rainfall events within lots and road reserves as much as practical, to reduce the size of stormwater quality treatment infrastructure with parkland. See Government of Western Australia (2014) and Western Australian Planning Commission and Department for Planning and Infrastructure (2009) for more information.

Footnotes for Figure 2

1 Water management plans include: water quality improvement plans, drainage and water management plans, district water management strategies, local water management strategies, urban water management plans, drinking water source protection reports, natural resource management strategies, and environmental protection policies, and the Healthy rivers action plan (SRT 2008) for the Swan and Canning catchments.

2 Sensitive receiving environments include the following environments, as defined in Guidance statement no. 33: Environmental guidance for planning and development (Environmental Protection Authority 2008): natural areas of high conservation significance (chapter B1.2.1), native vegetation and flora of high conservation significance (chapter B2.2.2), areas of high conservation significance for native terrestrial fauna (chapter B3.2.2), wetlands of high conservation significance (chapter B4.2.2), waterways of high conservation significance (chapter B5.2.2), waterways conservation areas and the Swan River Management Area (attachment B5-5), public drinking water source areas (chapter B6-1), landscapes and landforms of high conservation significance (chapter B8.2.1), and karst areas of high conservation significance (chapter B9.2.2). Water bodies are usually the receiving environment for stormwater runoff. Water bodies are defined as wetlands, waterways and their estuaries, coastal marine areas and shallow groundwater aquifers.

3 Retention systems prevent stormwater runoff, up to the design rainfall event. The water may infiltrate into the soil, be used as a water source, evaporate, or evapotranspirate. Detention systems reduce the rate of stormwater runoff by temporarily holding rainfall runoff (up to the design rainfall event) and then releasing it slowly.

4 The 15 mm rainfall criterion replaces the 1-year, 1-hour average recurrence interval (ARI) event criterion.

5 Pre-development refers to the conditions at the site immediately preceding the proposed development.

6 The critical 1 exceedance per year (EY) event criterion replaces but is equivalent to the critical 1-year ARI event criterion. EY expresses the probability of how many times in any year that event will occur. For example, a 2 EY event is expected to occur or be exceeded twice a year. The review of Australian rainfall and runoff (Engineers Australia n.d.) is recommending use of 1 EY for events previously categorised as 1-year ARI.

7 Consult with the Department of Water, the Environmental Protection Authority and Department of Parks and Wildlife (when in the Swan-Canning Rivers catchment) regarding changes to waterway management. Consult with the Department of Parks and Wildlife and the Environmental Protection Authority regarding changes to wetland management. Consult with the Water Corporation regarding changes to stormwater flows to a Water Corporation main drainage network. Consult with the local government regarding changes to stormwater flows to a local drainage network.

8 The 1% annual exceedance probability (AEP) criterion replaces but is equivalent to the 100-year ARI event criterion. AEP expresses the probability of an event occurring or being exceeded in any year; to be expressed as a percentage probability. The review of Australian rainfall and runoff (Engineers Australia n.d.) is recommending use of 1% AEP for events previously categorised as 100-year ARI.

9 Important community facilities, such as hospitals, require more freeboard due to the increased consequences from flooding. See Table 7.3.2 of Queensland's Department of Energy and Water Supply et al. (2013) for guidance on sensitive community facilities.

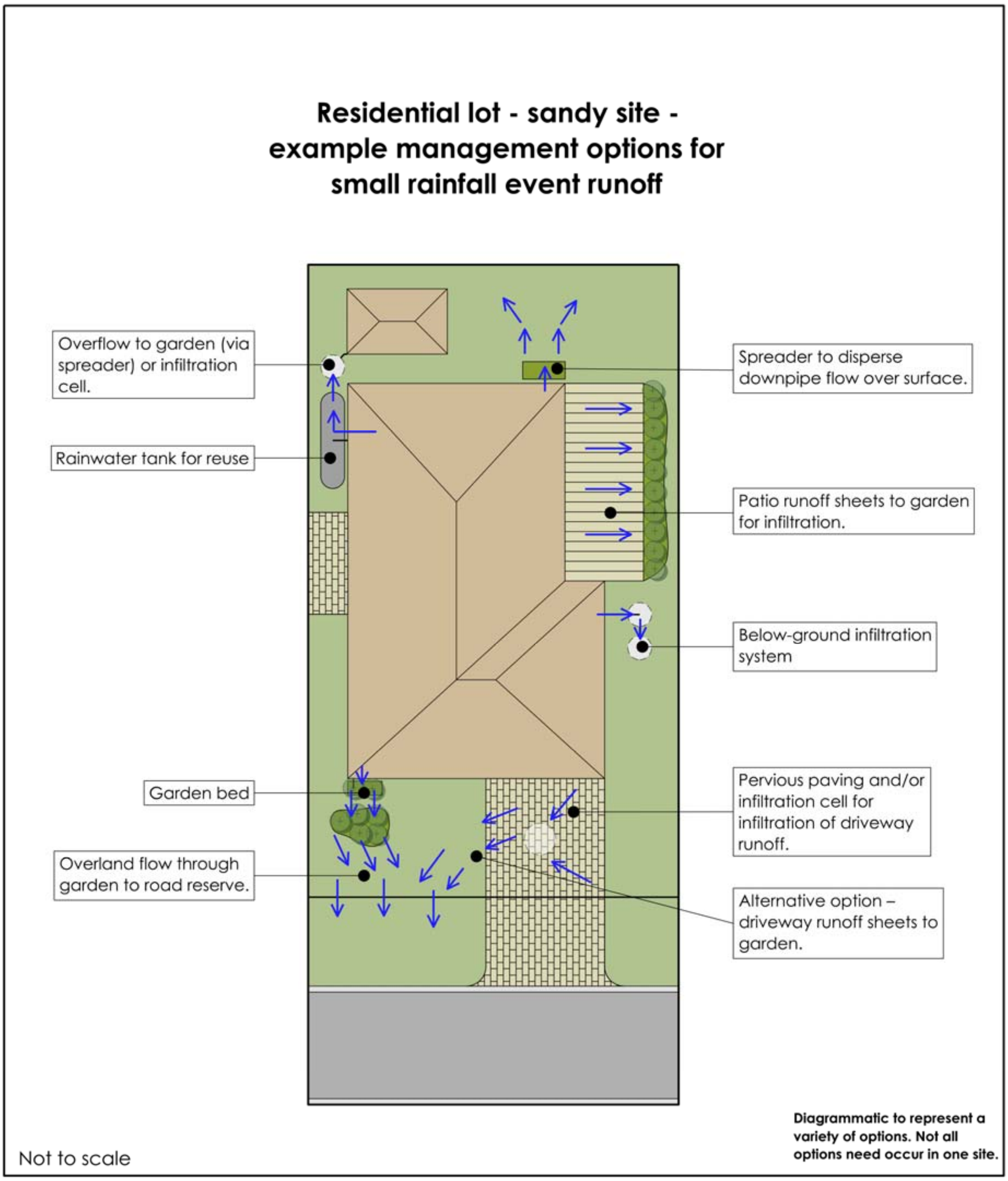

Figure 3 Example management options for residential lots with sandy soils – small rainfall event runoff

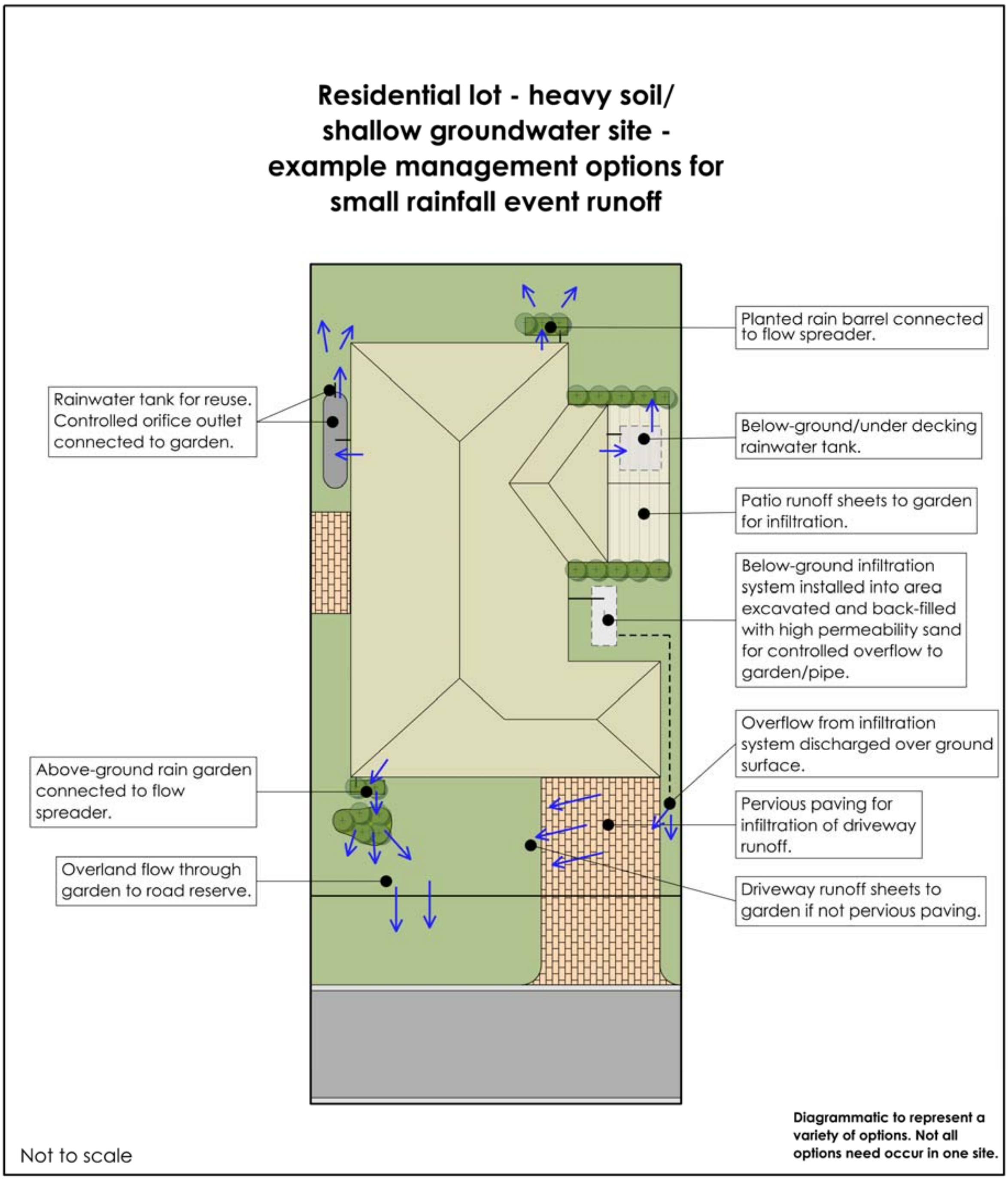

Figure 4 Example management options for residential lots with heavy soils/shallow groundwater – small rainfall event runoff

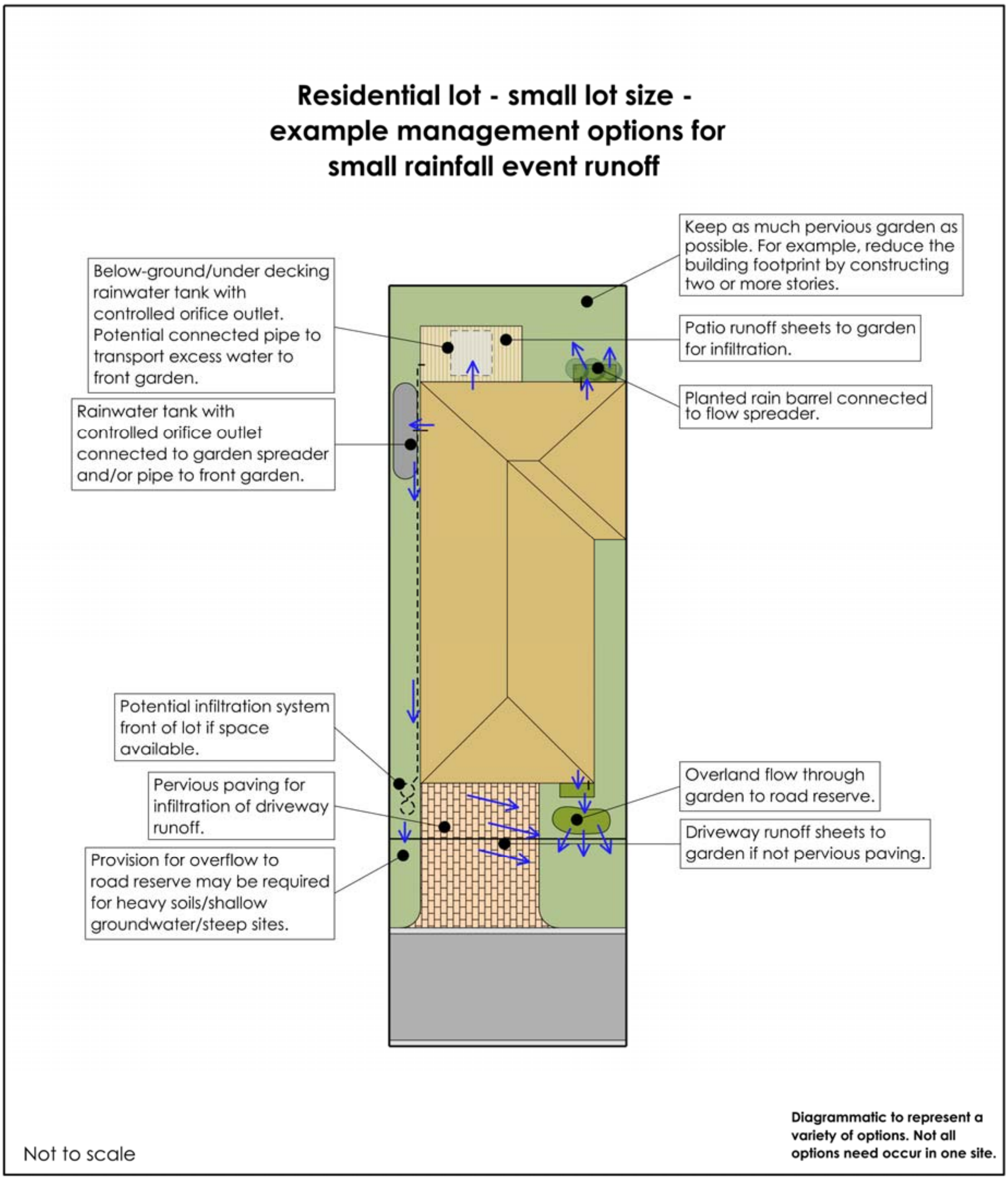

Figure 5 Example management options for residential lots on small sites – small rainfall event runoff

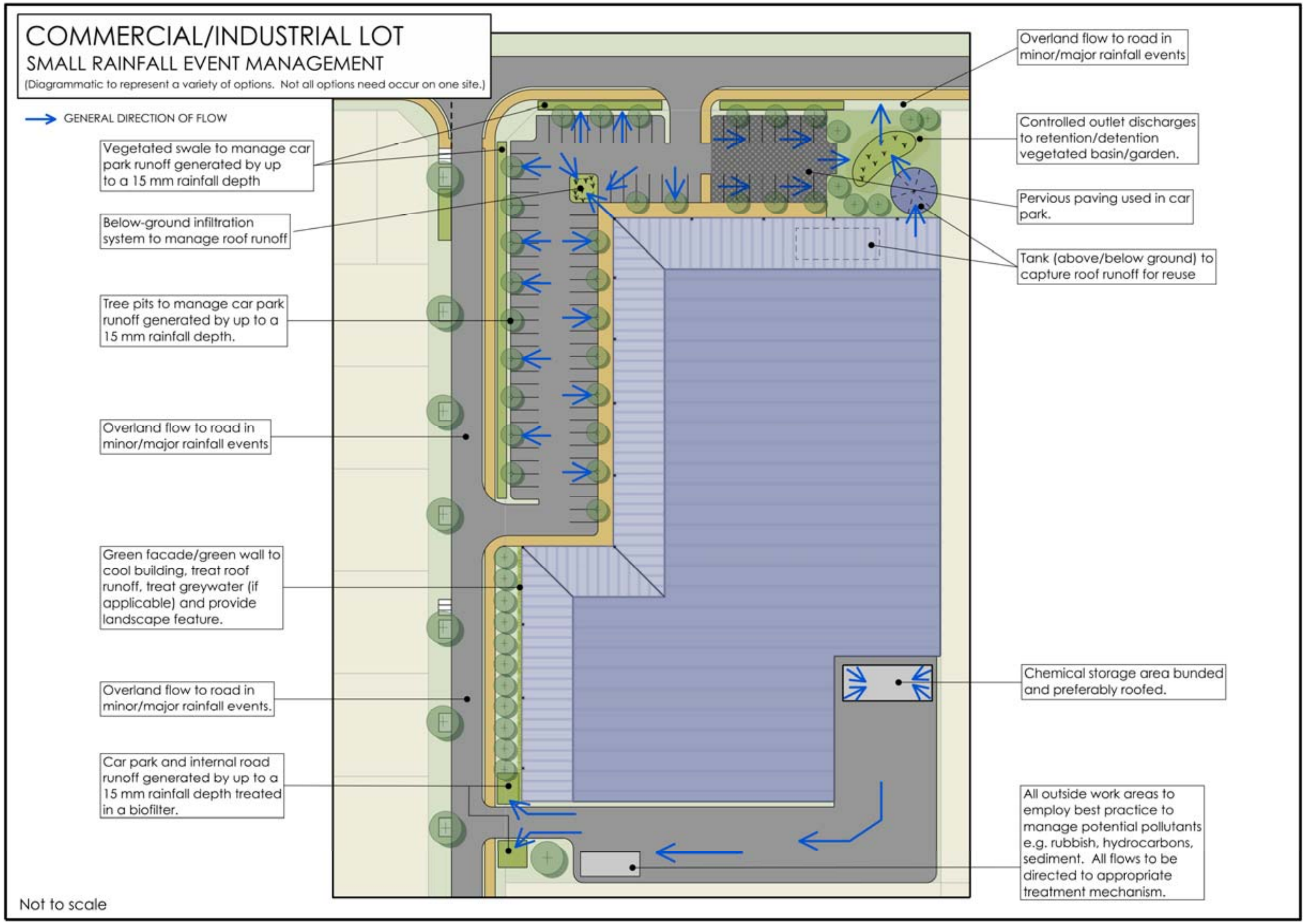

Figure 6 Example management options for commercial/industrial lots – small rainfall event runoff

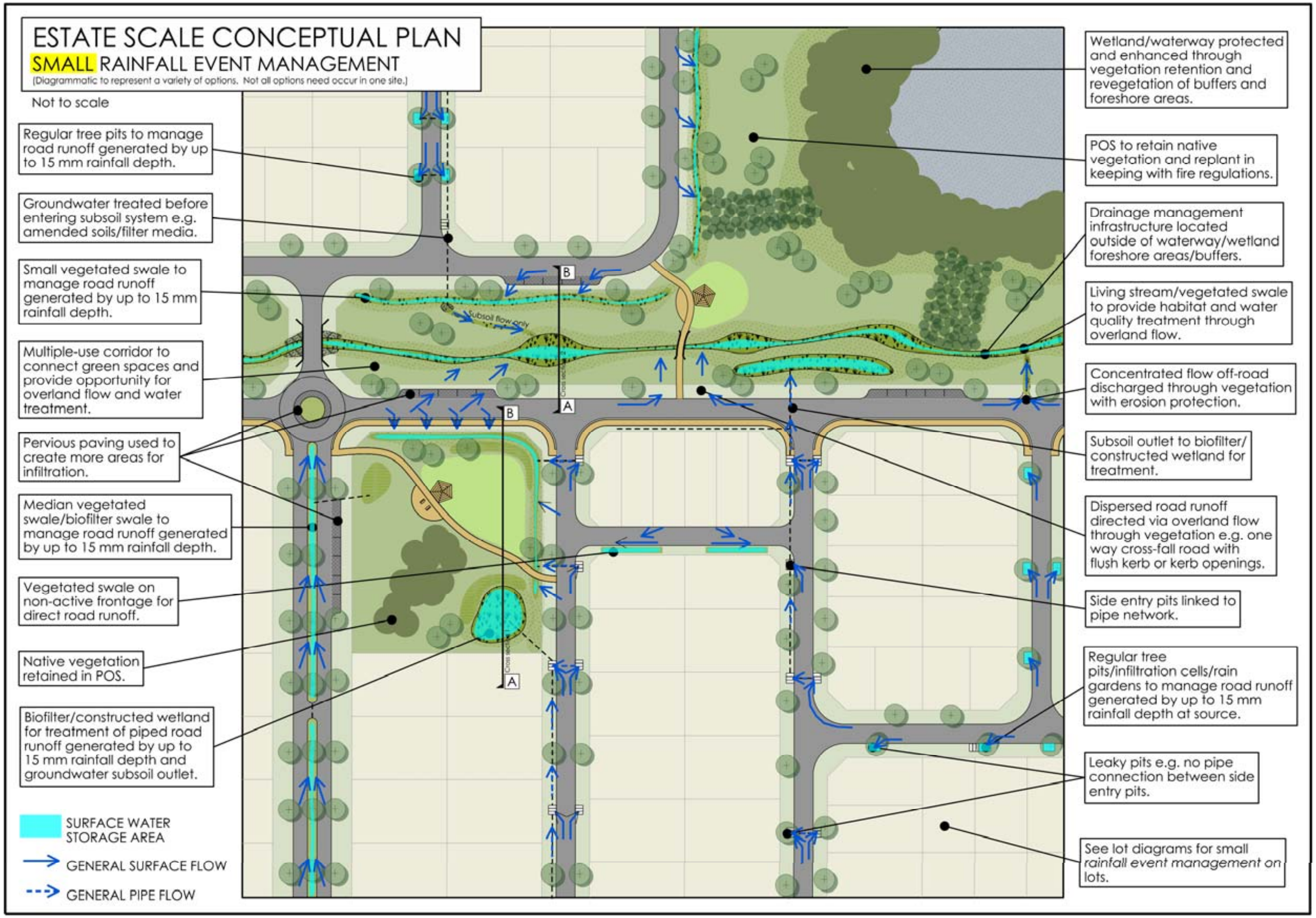

Figure 7 Example management options for estate scale – small rainfall event runoff

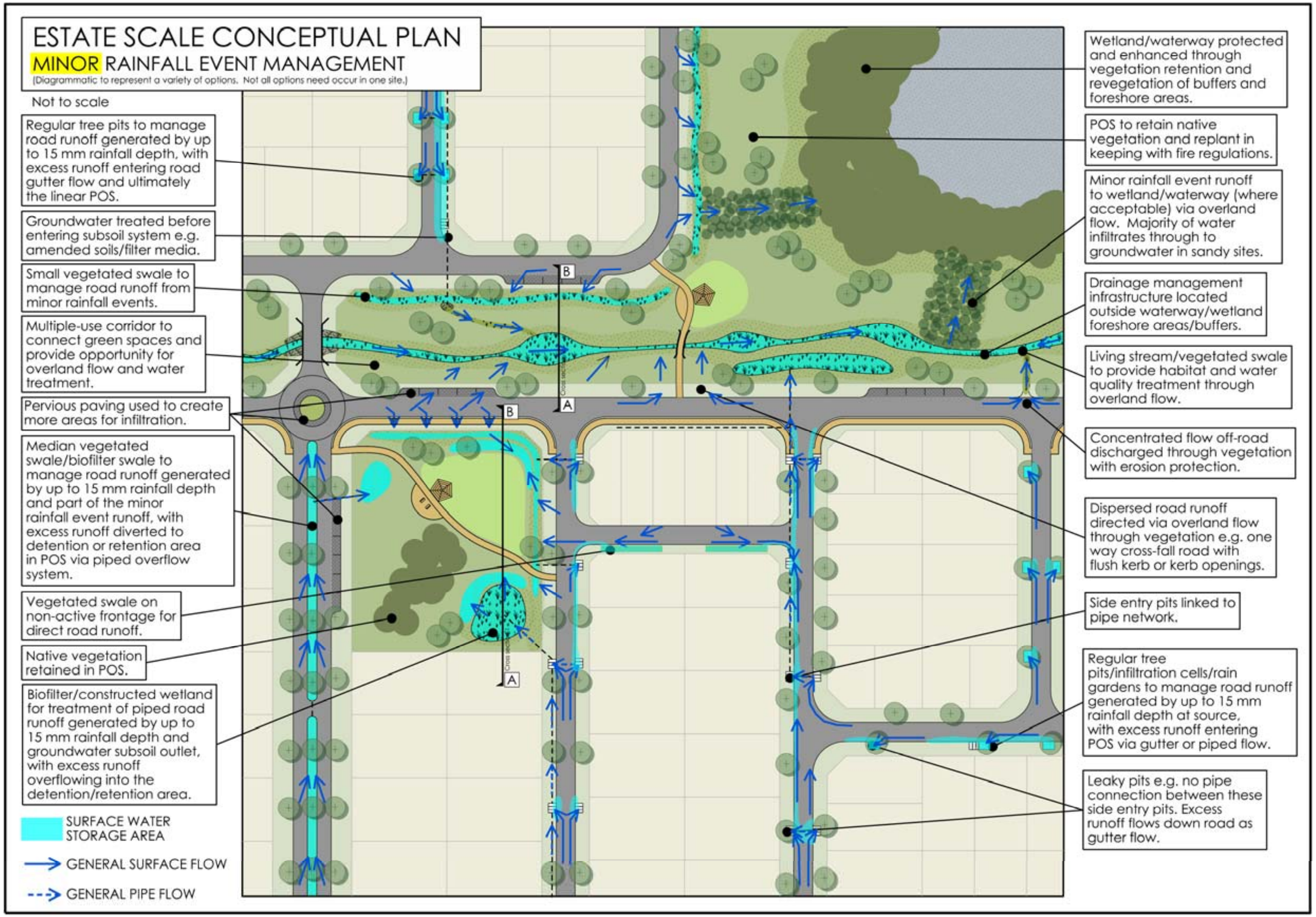

Figure 8 Example management options for estate scale – minor rainfall event runoff

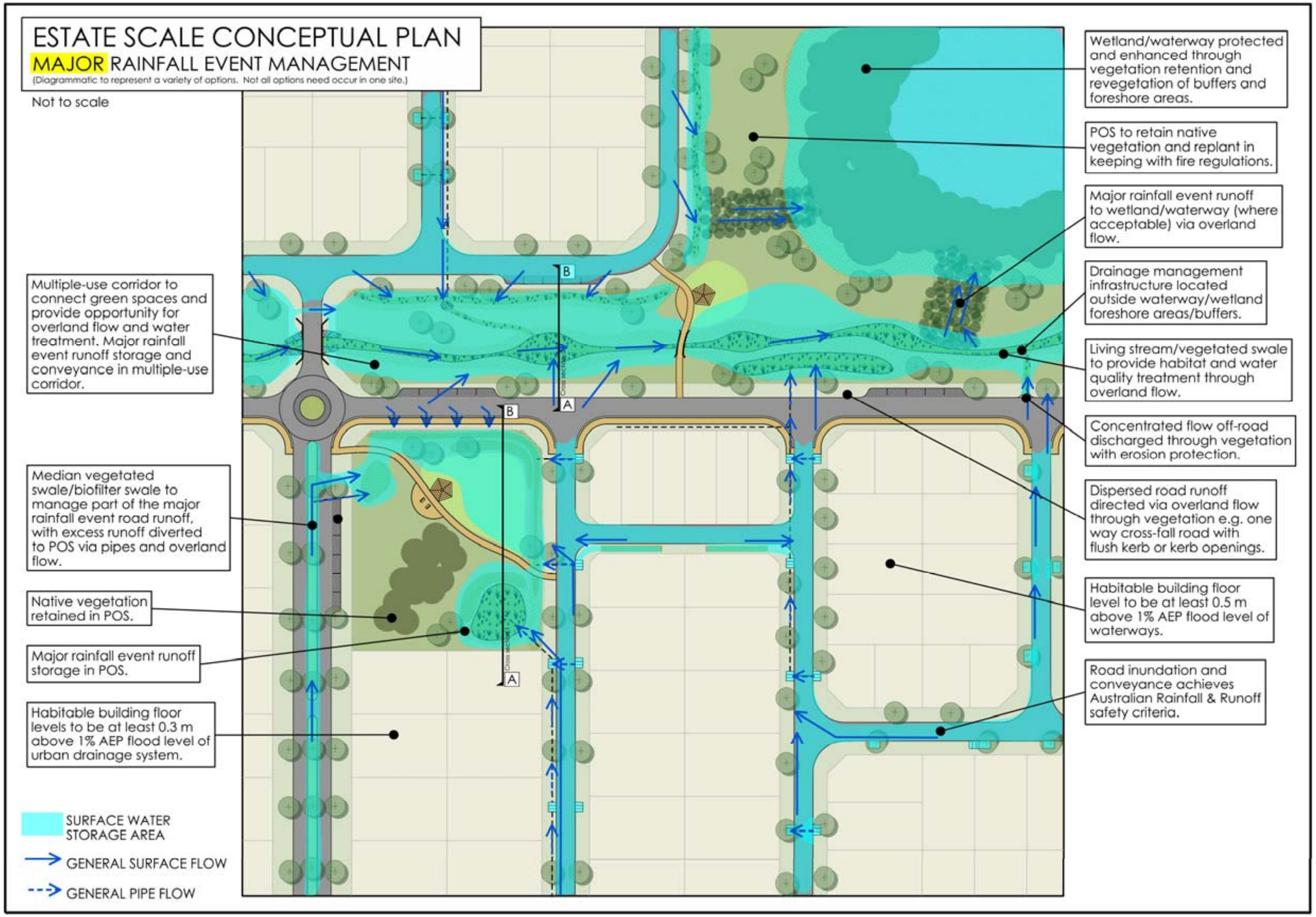

Figure 9 Example management options for estate scale – major rainfall event runoff

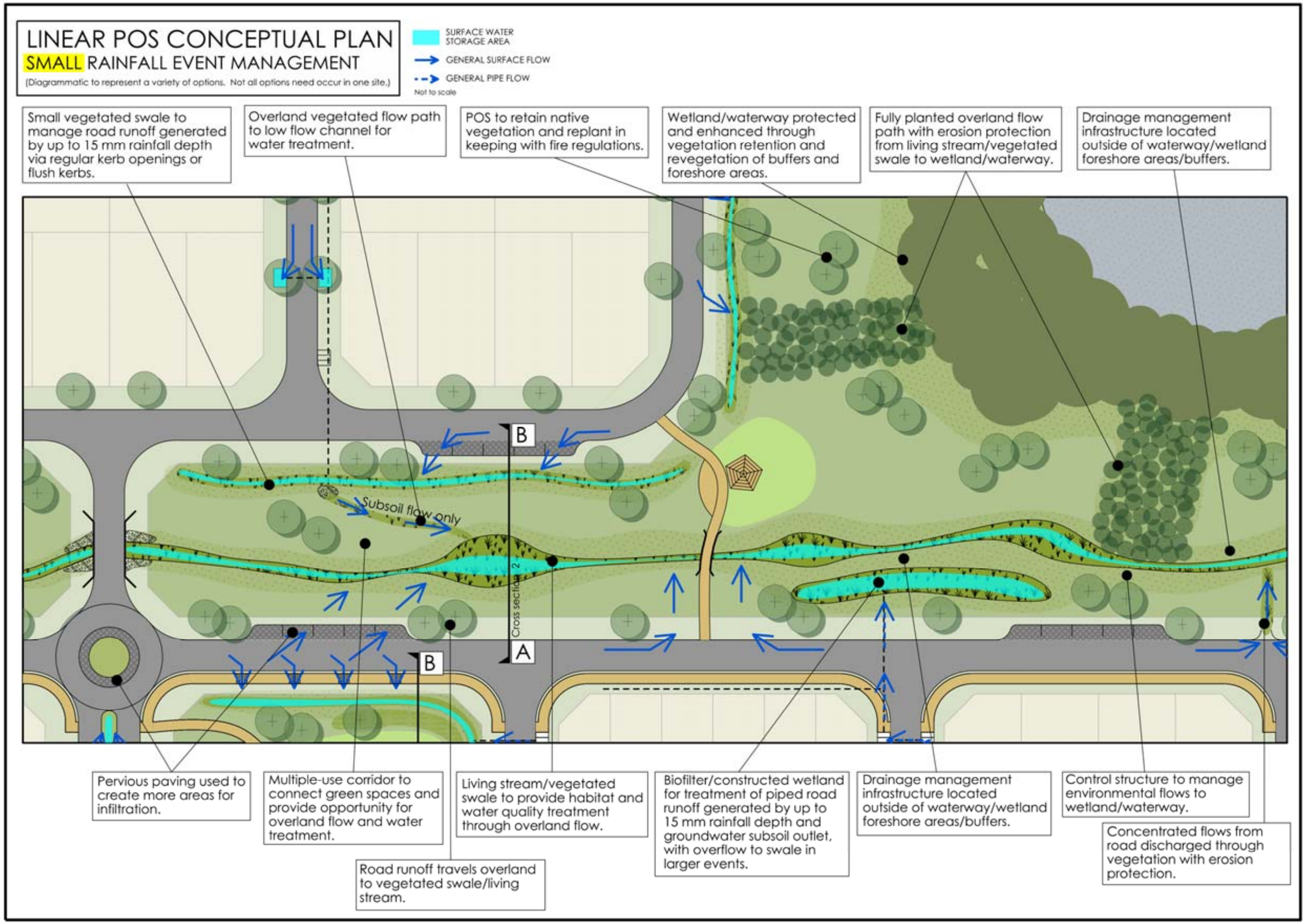

Figure 10 Example management options for linear public open space – small rainfall event runoff

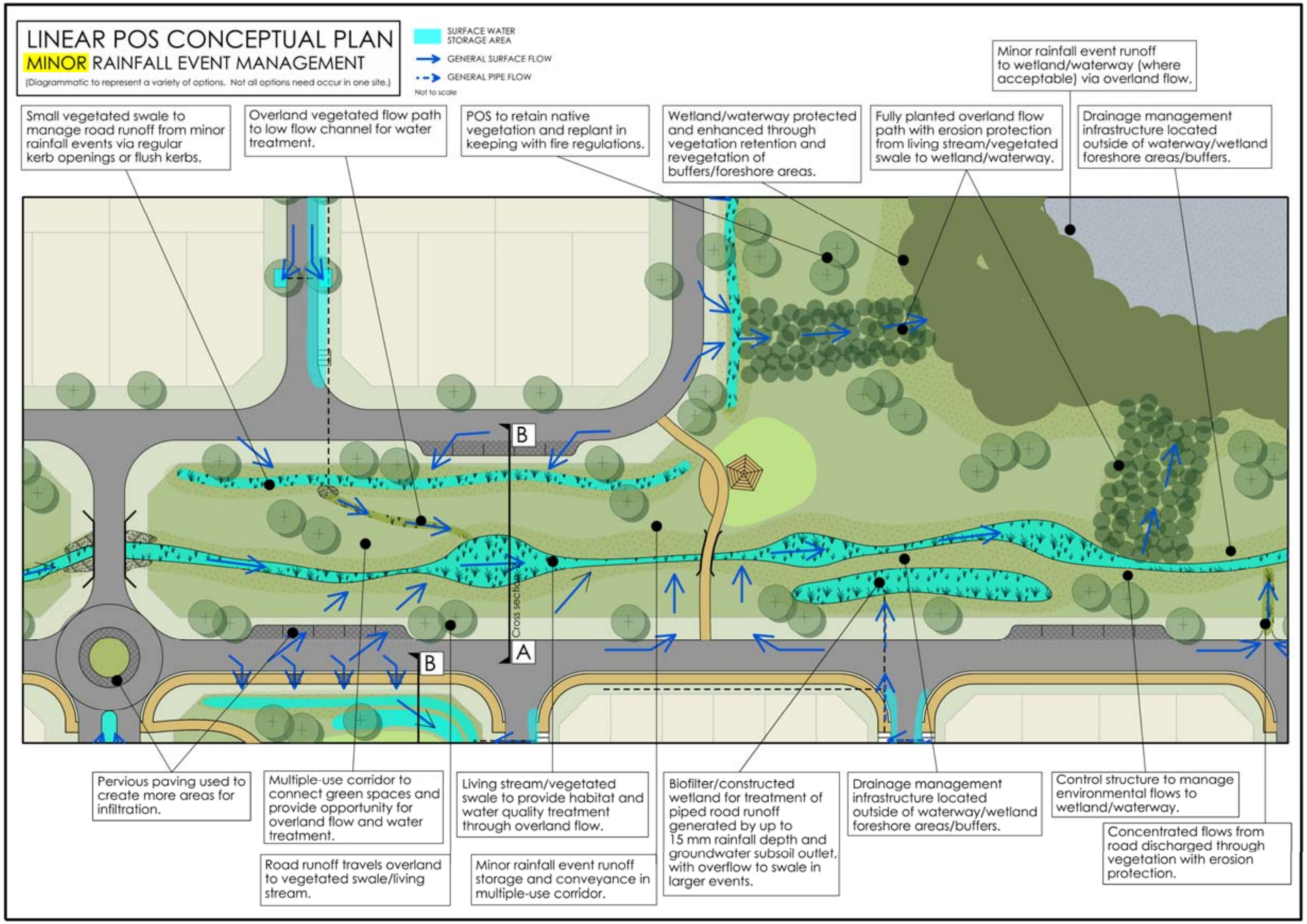

Figure 11 Example management options for linear public open space – minor rainfall event runoff

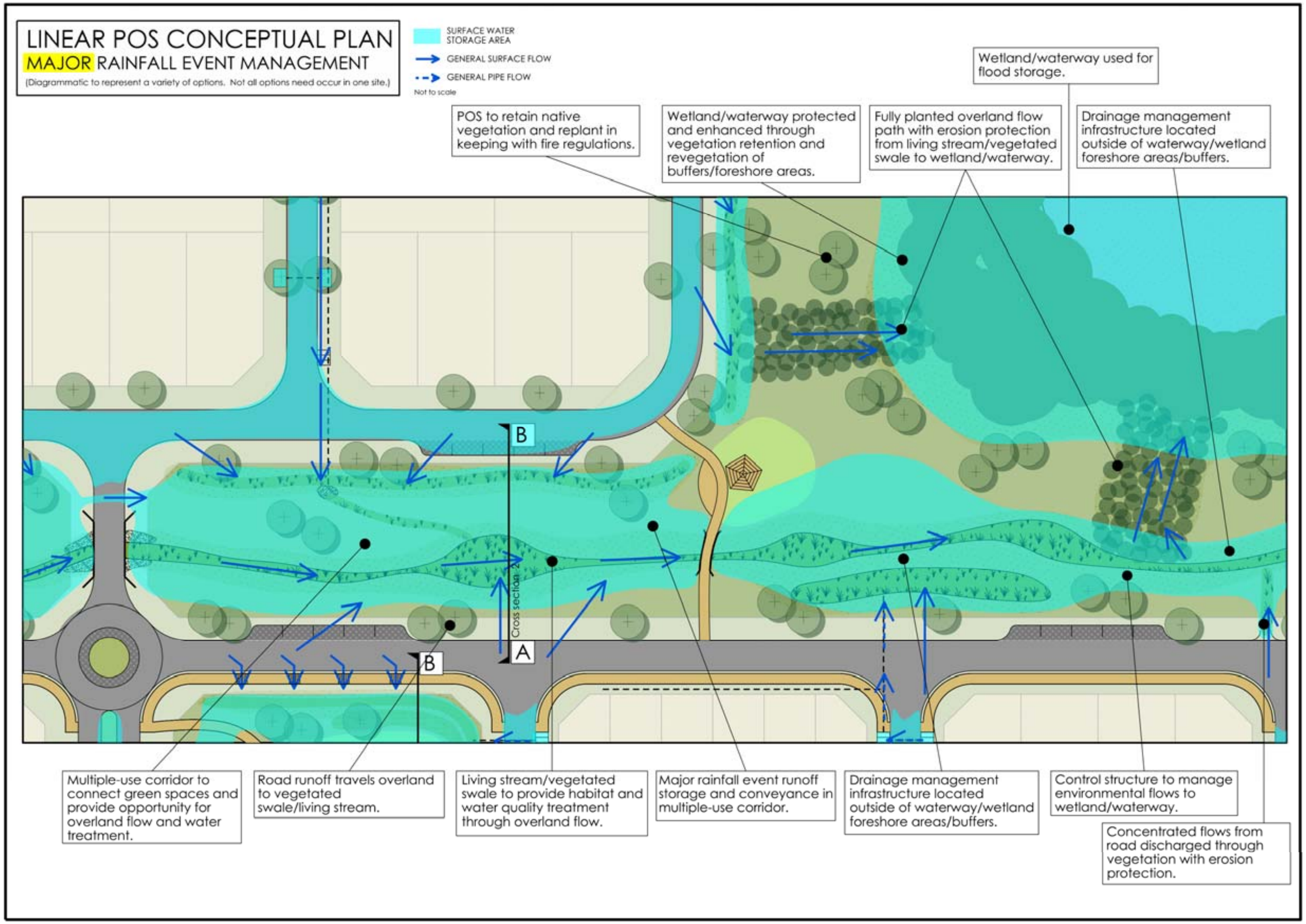

Figure 12 Example management options for linear public open space – major rainfall event runoff

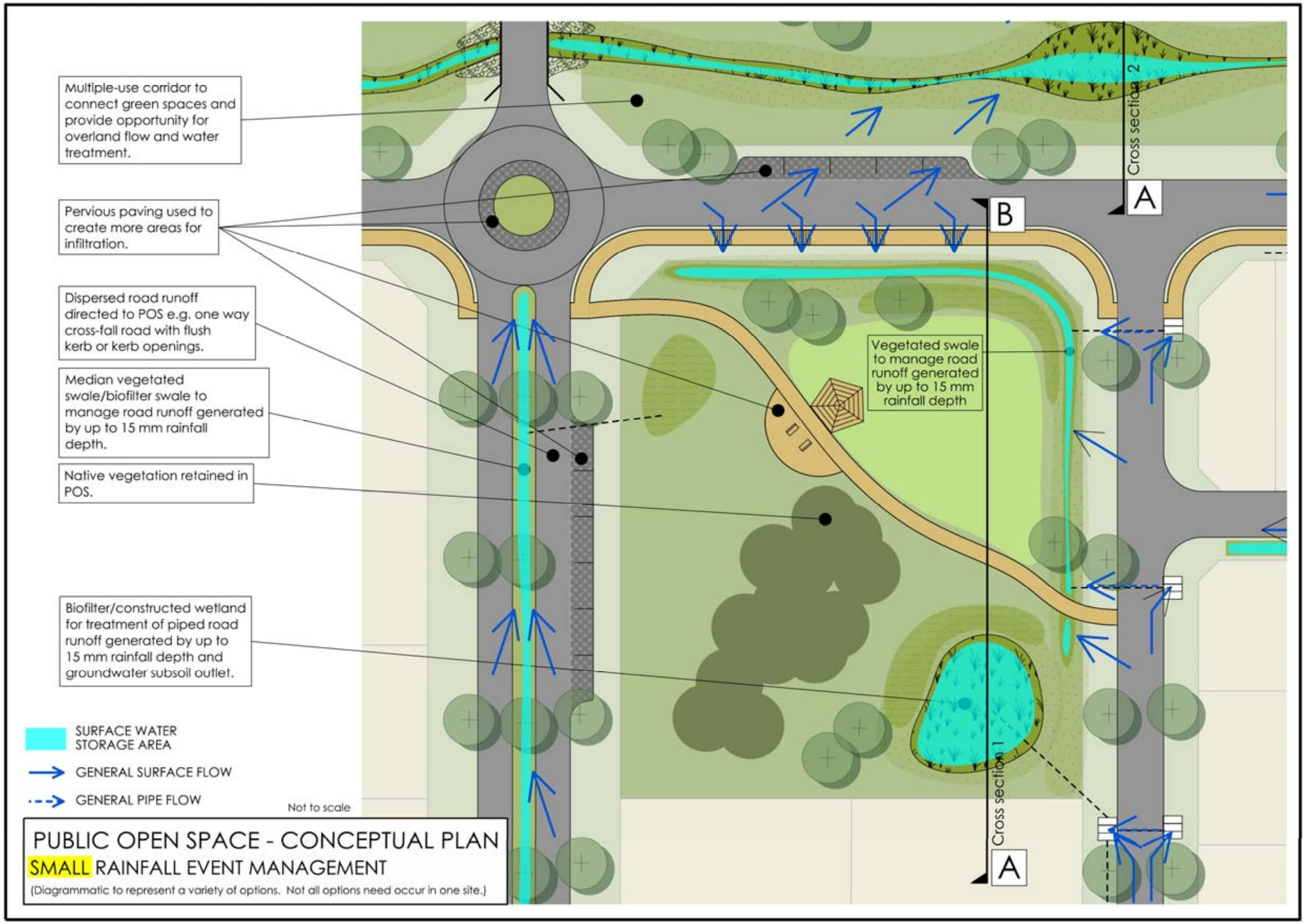

Figure 13 Example management options for public open space – small rainfall event runoff

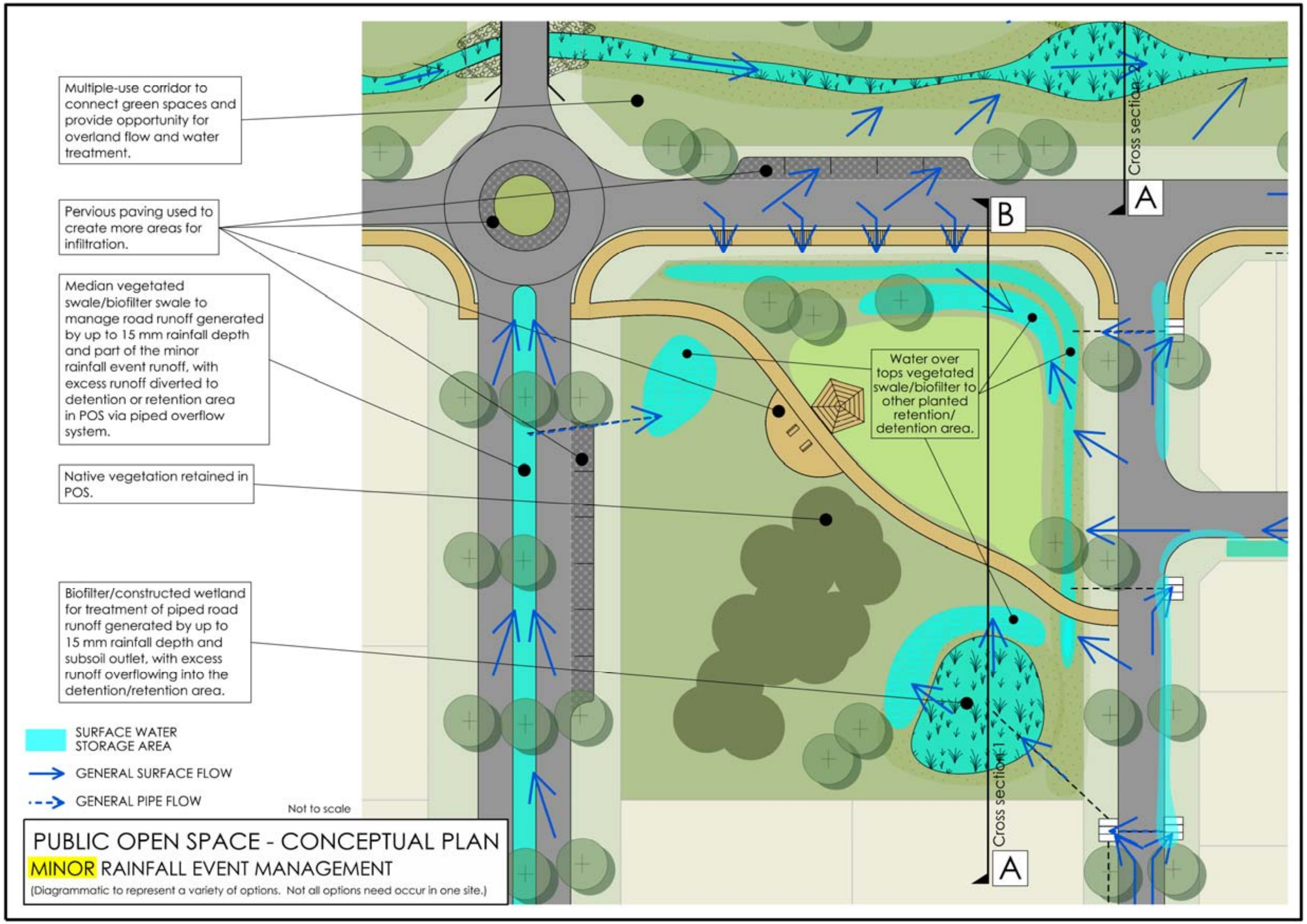

Figure 14 Example management options for public open space – minor rainfall event runoff

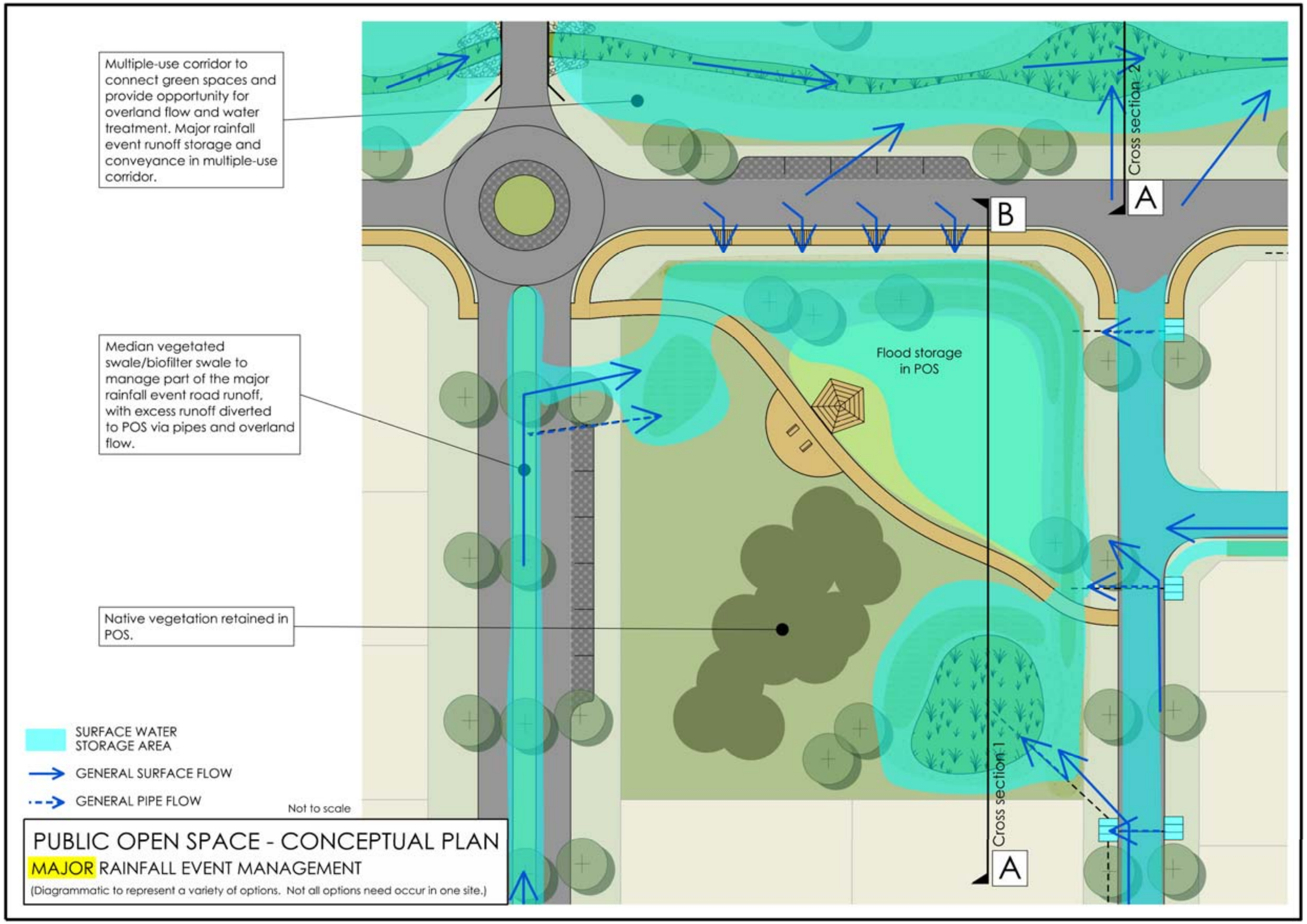

Figure 15 Example management options for public open space – major rainfall event runoff

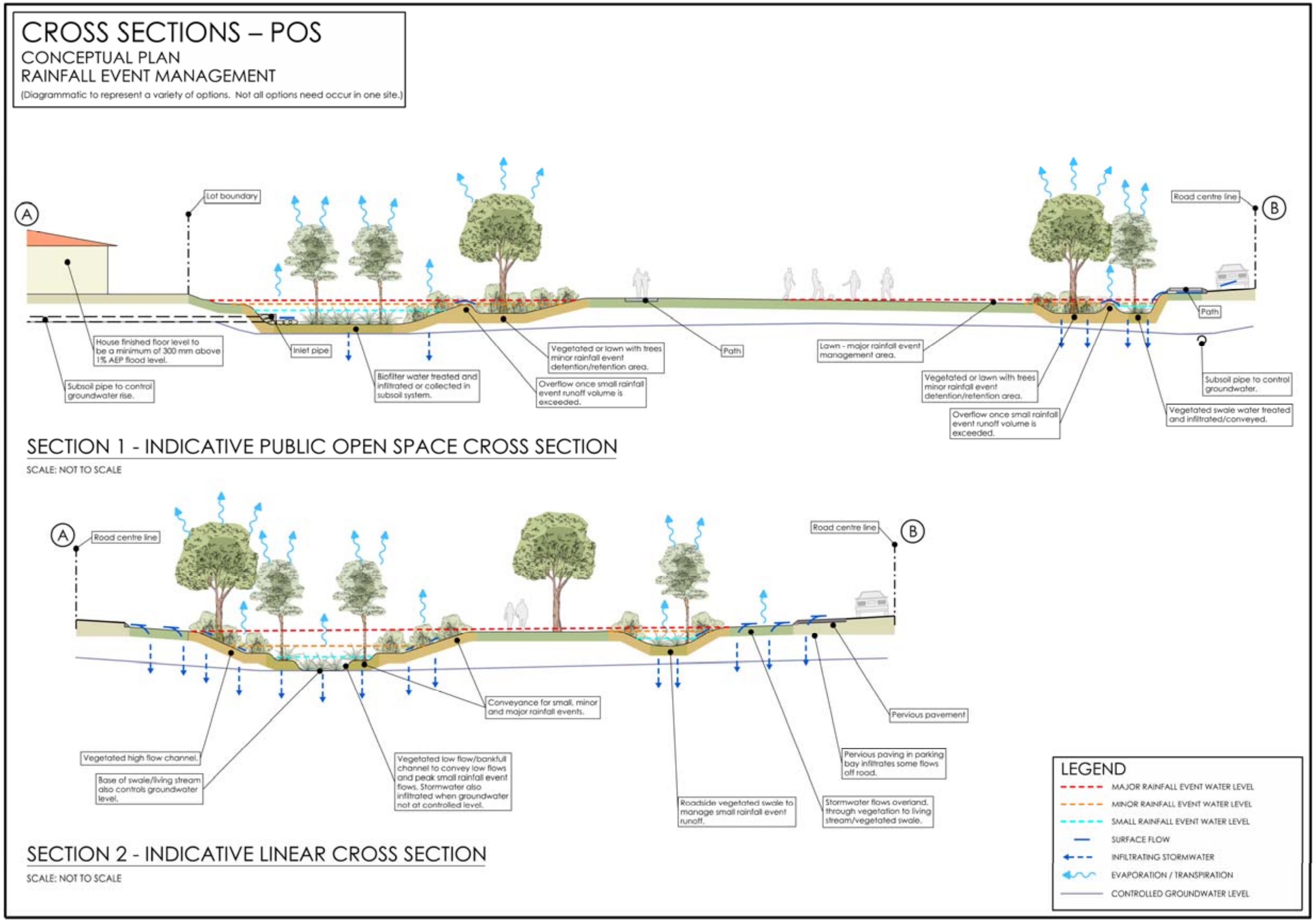

Figure 16 Cross-sections for public open space – all rainfall events

5 Conclusion

It is important to consider how water moves in the natural landscape and aim to replicate that in the design of site-specific stormwater management systems and urban form. The water sensitive stormwater management approach examines how runoff from small rainfall events is managed *and* how the minor and major rainfall events move through the urban landscape. When designing stormwater management systems, it is important to focus on what occurs most often, while understanding and planning for what occurs less frequently. So the design process should design for the small, then minor, then major rainfall events.

The desired outcomes of the *Decision process for stormwater management in WA* are for urban stormwater management systems to be planned and designed to achieve the following:

- Protect public health and safety.
- Protect public and private infrastructure and buildings from flooding.
- Protect and enhance sensitive receiving environments by managing the water cycle, water quality, habitat diversity and biodiversity.
- Provide economically sustainable construction, maintenance and renewal/replacement costs.
- Achieve good urban amenity.

Shortened forms

AEP	Annual exceedance probability
ARI	Average recurrence interval
DER	Department of Environment Regulation
DoW	Department of Water
DPaW	Department of Parks and Wildlife
DWMS	District water management strategy
EY	Exceedance per year
LG	Local government
LWMS	Local water management strategy
n.d.	No date
POS	Public open space
UWMP	Urban water management plan

Glossary

Annual exceedance probability (AEP)	Expresses the probability of an event occurring or being exceeded within a year; to be expressed as a percentage probability (Engineers Australia n.d.).
Average recurrence interval (ARI)	The average period between occurrences equalling or exceeding a given value (Engineers Australia n.d.).
Connected systems	All of the runoff from constructed impervious surfaces generated by the first 15 mm of rainfall directly enters a piped/lined channel system and is conveyed off the lot or off the road reserve.
Detention system	Reduces the rate of stormwater runoff by temporarily holding rainfall runoff (up to the design rainfall event) and then releasing it slowly.
Disconnected systems	All of the runoff from constructed impervious surfaces generated by the first 15 mm of rainfall flows onto pervious soil areas or into devices that provide for losses via infiltration, use and evaporation/transpiration and that achieve either retention and/or detention.
Effective imperviousness	The combined effects of the proportion of constructed impervious surfaces in the catchment (‘total imperviousness’) and the connectivity of these impervious surfaces to receiving water bodies (‘drainage connection’; (Walsh et al. 2004).
Exceedance per year (EY)	Expresses the probability of how many times in any year that event will occur (Engineers Australia n.d.). For example, a 2 EY event is expected to occur or be exceeded twice a year.
Major rainfall event	Includes events greater than the minor rainfall event and up to and including the 1% annual exceedance probability event.
Minor rainfall event	Rainfall events greater than small rainfall events and less than major rainfall events. The effects of minor rainfall events on transport networks, public open space and drainage networks should be assessed. The minor rainfall event management system should be designed to provide serviceability, amenity and road safety. Providers of transport networks, public open space and drainage networks should define the relevant exceedance per year or the annual exceedance probability.
Non-structural controls	Institutional and pollution-prevention practices designed to prevent or minimise contaminants from entering stormwater runoff and/or reduce the volume of stormwater requiring management.
Pre-development	The conditions at the site immediately preceding the proposed development.
Relevant agency	Consult with the Department of Water, the Environmental Protection

	Authority and Department of Parks and Wildlife (when in the Swan-Canning Rivers catchment) regarding changes to waterway management. Consult with the Department of Parks and Wildlife and the Environmental Protection Authority regarding changes to wetland management. Consult with the Water Corporation regarding changes to stormwater flows to a Water Corporation main drainage network. Consult with the local government regarding changes to stormwater flows to a local drainage network.
Retention system	Prevents stormwater runoff, up to the design rainfall event. The water may infiltrate into the soil, be used as a water source (e.g. by vegetation or for toilet flushing), or evaporate.
Sensitive receiving environments	Include the following environments, as defined in *Guidance statement no. 33: Environmental guidance for planning and development* (Environmental Protection Authority 2008): natural areas of high conservation significance (Chapter B1.2.1), native vegetation and flora of high conservation significance (Chapter B2.2.2), areas of high conservation significance for native terrestrial fauna (Chapter B3.2.2), wetlands of high conservation significance (Chapter B4.2.2), waterways of high conservation significance (Chapter B5.2.2), waterways conservation areas and the Swan River Management Area (attachment B5-5), public drinking water source areas (Chapter B6-1), landscapes and landforms of high conservation significance (Chapter B8.2.1), and karst areas of high conservation significance (Chapter B9.2.2). Water bodies are usually the receiving environments for stormwater runoff. Water bodies are defined as wetlands, waterways and their estuaries, coastal marine areas and shallow groundwater aquifers.
Small rainfall event	The first 15 mm of a rainfall event.
Stormwater	Water that is flowing over ground surfaces and in natural streams and drains, as a direct result of rainfall over a catchment. Stormwater consists of rainfall runoff and any material (soluble and insoluble) mobilised in its path of flow (Department of Water 2004).
Stormwater system	A stormwater system can be one stormwater infrastructure device or a combination of stormwater infrastructure devices forming a treatment train.
Structural controls	Engineered devices implemented to manage runoff quality and quantity, to control, treat or prevent stormwater pollution and/or reduce the volume of stormwater requiring management.
Urban development	Residential, rural-residential, commercial and industrial development (includes regional towns). It does not include heavy industrial development.
Urban drainage system	The system of overland flow paths, channels and pipes that drain an urban catchment area.
Water bodies	Wetlands, waterways and their estuaries, coastal marine areas and shallow groundwater aquifers.
Waterway	Any river, creek, stream or brook, including its floodplain and estuary. This

	includes systems that flow permanently, for part of the year or occasionally; and parts of the waterway that have been artificially modified.
Water quality treatment infrastructure	Infrastructure for treatment of small rainfall event runoff from constructed impervious surfaces that directly enters a piped/lined channel system and is conveyed off the lot or off the road reserve, and for treatment of controlled groundwater level outlets. Examples are vegetated stormwater treatment systems, such as vegetated swales, biofilters and constructed wetlands, or proprietary water quality treatment devices. When sizing the water quality treatment system, factor in the expected losses. When deciding on the type of water quality treatment infrastructure to be used, the types of pollutants and level of risk (e.g. to the receiving environments and from the pollutant type/land-use type) indicate the treatment infrastructure. Water quality treatment for subsoil drains may also be achieved by placing appropriate soil media underneath and to the sides of the pipe filter pack to treat the groundwater before entering the pipe.
Water sensitive city	A water sensitive city combines physical infrastructure (water sensitive urban design and integrated urban water management) with social systems (governance and engagement) to create a city in which the connections that people have with their water infrastructure and services enhances their value and quality of life (Wong et al. 2013).
Water sensitive urban design	A design philosophy that provides a framework for managing water-related issues in urban areas. WSUD incorporates the sustainable management and integration of stormwater, groundwater, wastewater and water supply into urban design. WSUD principles include incorporating water resource management issues early in the land use planning process. WSUD can be applied at the lot, street, neighbourhood, catchment and regional scale.

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